TITLE OF THE INVENTION:

Method and Apparatus For Installing a Helical Pile

FIELD OF THE INVENTION

This invention relates to a method and an apparatus that may be used to install a helical or screw pile.

BACKGROUND OF THE INVENTION

Helical or screw piles have been used for decades to help support the foundation of buildings, bridges and other civil engineering structures. Traditionally helical piles were used primarily in areas of weak or wet soil and their application was somewhat limited as their installation was difficult without mechanical assistance. However, more recently helical piles have become considerably more widespread in use due to the advent of high torque motors that are used to rotate the piles and drive them into the ground. The resistence of a helical pile to both upward and carrying loads makes it attractive for use in a wide range of different situations. Today helical or screw piles are commonly used in foundation support for commercial and residential buildings, to help support temporary structures, as a support for street light standards, for the support of oil and gas drilling and pumping equipment, for bank retention, and for a wide variety of anchoring applications.

Typically a helical pile is installed through the use of a boom truck having a high torque motor positioned on the end of a boom that may be connected to the upper end of the pile in order to rotate the pile and drive it into the ground. Torque is transferred from the motor to the pile through the use an intermediary coupling that is either physically welded to the end of the pile or fastened thereto through the use of bolts, pins or some other mechanical fastener. While such a structure is effective in transmitting rotational movement from the motor to the pile, it can also require a considerable amount of labour to put into operation on account of the need to weld,

bolt, pin or otherwise secure the torque coupling to the end of the pile.

In many instances piles of significant length are required, which either necessitates the use of a large boom truck having an extended reach or requires that a number of lengths of shorter piling be welded or fastened together as they are driven into the ground. Where a large boom truck is used to drive a lengthy helical pile, difficulties can arise when trying to maintain the pile in a vertical orientation due to the length of the pile and the weight of the drive motor that is attached to its upper end.

The cost of utilizing a trunk having an extruded boom can be significant. Large boom trucks also restrict the ability to work in confined areas. In cases where a pile is to be installed in sections, existing equipment makes it necessary to physically attach (and then later remove) the intermediary drive member, to each length of pile. Attaching, removing and subsequently re-attaching the drive member is both time consuming and costly.

There is therefore a need for an improved apparatus for installing a helical or screw pile, particularly where the pile is of significant length.

SUMMARY OF THE INVENTION

The invention therefore provides a method and an apparatus that may be used to install a helical or screw pile whereby the need for the use of a large boom truck is eliminated or minimized, as is the requirement for physically welding, bolting or pinning an intermediary drive member or torque coupling to the end of the pile in order to connect the pile to the motor of a drive head. The invention provides for a drive mechanism that imparts rotational movement to a pile without appreciable movement or displacement of the drive mechanism in a direction generally parallel to the longitudinal axis of the pile.

Accordingly, in one of its aspects the invention provides an apparatus to assist in the installation of a helical pile, the apparatus comprising a drive mechanism operatively connected to a power source, said power source causing said drive mechanism to move in a first direction and then subsequently in a second direction in a reciprocating fashion, said drive mechanism having an engaged and a disengaged configuration, when in said engaged configuration said drive mechanism operatively gripping the exterior surface of said helical pile, when in said disengaged configuration said drive mechanism operatively releasing the exterior surface of said helical pile, movement of said drive mechanism in said first direction placing said drive mechanism in said engaged configuration and causing rotational movement of said helical pile, movement of said drive mechanism in said second direction placing said drive mechanism in said disengaged configuration without rotation of

said helical pile.

In a further aspect the invention provides a method of installing a helical pile, the method comprising the steps of operatively connecting a drive mechanism having an engaged and a disengaged configuration to a power source, when in said engaged configuration said drive mechanism capable of gripping the exterior surface of the helical pile, when in said disengaged configuration the drive mechanism releasing the exterior surface of the helical pile; with said power source operating said drive mechanism to move said drive mechanism in a first direction that places said drive mechanism in said engaged configuration such that further movement of said drive mechanism in said first direction causes rotational movement of said pile; and, thereafter, causing said power source to move said drive mechanism in a second direction thereby placing said drive mechanism in said disengaged configuration without rotation of said helical pile.

The invention also provides an apparatus to assist in the installation of a helical pile, the apparatus comprising a drive mechanism having an engaged and a disengaged configuration, when in said engaged configuration said drive mechanism operatively gripping the exterior surface of said helical pile, when in said disengaged configuration said drive mechanism operatively releasing the exterior surface of said helical pile, wherein movement of said drive mechanism when in said engaged configuration causes rotational movement of said pile, when in said disengaged configuration said drive mechanism moving without rotation of said pile.

In another aspect the invention concerns a method of installing a helical pile, the helical pile being of the type having a generally hollow longitudinally orientated bore extending therethrough, the method comprising the steps of (i) with a drive mechanism imparting rotational movement to the pile to cause the pile to be rotated into the ground; and, (ii) extracting at least a portion of any accumulated soil or debris from within the pile's hollow bore.

The invention also provides an apparatus to assist in the installation of a helical pile of the type having a generally hollow longitudinally orientated bore extending therethrough, the apparatus comprising a drive mechanism and a soil extractor, said drive mechanism imparting rotational movement to the pile to cause the pile to be rotated into the ground, said soil extractor operable to extract at least a portion of any accumulated soil or debris from within the pile's hollow bore.

In a further alternate embodiment the invention provides an apparatus to assist in the installation of a helical pile, the apparatus comprising a drive mechanism operatively connected to a power source, said power source causing said drive mechanism to move in a first direction and then subsequently in a second direction in a reciprocating fashion, said drive mechanism operatively connected to the exterior surface of said helical pile such that reciprocal movement of said drive mechanism causes rotational movement of said helical pile without appreciable movement or displacement of said drive mechanism in a direction generally parallel to the longitudinal axis of said pile.

In yet as further aspect the invention concerns an apparatus to assist in the installation of a helical pile, the apparatus comprising a drive mechanism operatively connected to a power source and to the exterior surface of said helical pile, said power source causing said drive mechanism to impart rotational movement to said helical pile without appreciable movement or displacement of said drive mechanism in a direction generally parallel to the longitudinal axis of said pile.

Further aspects and advantages of the invention will become apparent from the following description taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawings which show the preferred embodiments of the present invention in which:

Figure 1 is a side view of a street light standard as it would typically be supported upon a helical pile;

Figure 2 is a side view of an apparatus constructed in accordance with a preferred embodiment of the present invention;

Figure 3 is a front view of the apparatus shown in Figure 2;

Figure 4 is a plan view along the line 4-4 in Figure 1 showing a pile guide in accordance with one embodiment of the present invention;

Figure 5 is a plan view along the line 5-5 in Figure 1 showing a pile drive mechanism in accordance with one embodiment of the present invention;

Figure 6 is a plan view along the line 6-6 in Figure 1 showing a vertical loading head, in accordance with a preferred embodiment of the present invention;

Figure 7 is a plan view of the vertical loading head shown in Figure 6 in an open position;

Figure 8 is a side view of the vertical loading head shown in Figure 6;

Figure 9 is a partial exploded plan view of the vertical loading head shown in Figure 6;

Figure 10 is a sectional view taken along the line 10-10 in Figure 6;

Figure 11 is a partial side view of an alternate embodiment of the pile drive mechanism shown in Figure 2;

Figure 12 is a partial plan view of a third embodiment of the pile drive mechanism shown in Figure 2;

Figure 13 is a partial plan view of a fourth embodiment of the pile drive mechanism shown in Figure 2;

Figure 14 is a partial plan view of a fifth embodiment of the pile drive mechanism shown in Figure 2;

Figure 15 is a side view of an alternate embodiment of the apparatus shown in Figure 2;

Figure 16 is a partial plan view of an alternate drive mechanism pursuant to one embodiment of the invention; and,

Figure 17 is a sectional view taken along the line 17-17 in Figure 16.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention may be embodied in a number of different forms. However, the specification and drawings that follow describe and disclose only some of the specific forms of the invention and are not intended to limit the scope of the invention as defined in the claims that follow herein.

By way of introduction, Figure 1 shows a typical street light standard 1 that is anchored to the ground through the use of a helical or screw pile 2. Most commonly helical pile 2 will be comprised of an elongate, generally hollow, cylindrical body or pipe having at its lower end a helical thread attached thereto such that rotation of the pipe causes the pile to be screwed or augered into the ground.

Figures 2 and 3 show a preferred embodiment of the present invention as it would typically be connected to a boom truck or vehicle 3. From a thorough understanding of the invention it will be understood that the apparatus constructed in accordance with the invention described herein may in some instances be attached to a boom truck or other vehicle while other cases it may be self-contained on its own platform or skid, particularly where its use is required in confined areas. For illustration purposes an embodiment of the invention mounted upon a boom truck 3 (as shown in Figures 2 and 3) will be described in detail below.

According to the invention there is provided an apparatus 4 to assist in the installation of a helical or screw pile 2. Apparatus 4 is comprised generally of a drive mechanism 5 that is operatively connected to a power source 6. It is expected that in most instances power source 6 will be comprised of a hydraulic pump capable of providing pressurized hydraulic fluid to the various components of apparatus 4 where required. Alternately, power source 6 could be pneumatic or electrical in nature. In any event, power source 6 is operatively connected to drive mechanism 5 in order to allow for movement of the drive mechanism in a first direction, and then subsequently in a second direction, in a generally reciprocating fashion. In the embodiment of the invention shown in Figures 2 and 3, the reciprocating movement of drive mechanism 5 is accomplished through the use of a hydraulic or pneumatic cylinder 7. However, as discussed above, movement may also be achieved through the use of an electric solenoid or through the utilization of a mechanical linkage having a rotary gear or cam drive (not shown) allowing for reciprocal movement of the drive mechanism.

As is shown particularly in Figures 2 and 5, in one embodiment of the invention drive mechanism 5 includes a drive chain 8 that is received about the exterior surface of helical pile 2. In order for the apparatus to function as intended drive chain 8 must completely encircle the exterior surface of the helical pile. In Figures 2 and 5 chain 8 is shown wrapped around the pile one and one-half times. Drive chain 8 has a first end 9 secured to the reciprocating drive member, which in the case of Figures 2 and 5 is hydraulic cylinder 7. The second end 10 of drive chain 8 is secured to a

tensioning device 11 that may be a spring (as in Figures 2 and 5) or, alternatively, any one of a wide variety of other tensioning devices which could include hydraulic or pneumatic cylinders or electric solenoids. The opposite ends of hydraulic cylinder 7 and tension device 11 that are not connected to drive chain 8 are securely fastened to a portion of the frame 12 of apparatus 4 such that retraction of the piston within cylinder 7 causes a tightening of drive chain 8 about the exterior surface of helical pile 2. At that point drive mechanism 5 is placed in an engaged configuration with the drive chain securely gripping the exterior surface of pile 2. Once chain 8 is firmly gripped about the exterior surface of pile 2, further retraction of the piston within cylinder 7 causes movement of the chain in a first direction toward cylinder 7, and a resulting rotational movement of the helical pile. Rotation of the pile forces it to be driven or screwed into the ground. Depending upon the nature of the auger on the end of the pile, chain 8 may be wrapped in either a clockwise or counterclockwise manner around the pile's surface, as required to drive the pile in a desired direction. Movement of drive mechanism 5 in this manner may be referred to as a power stroke.

Once hydraulic cylinder 7 has reached the end of its movement in its first direction away from pile 2, the flow of hydraulic fluid may be reversed to allow the piston to be drawn outwardly from the cylinder toward the pile thereby relieving the tension in drive chain 8. As the tension in the drive chain is relieved, drive mechanism 5 will proceed to a disengaged configuration where chain 8 is released from its gripping contact with the exterior surface of helical pile 2. The chain will then be

pulled or slid in an opposite direction (ie with second end 10 moving away from the pile) through the operation of tensioning device 11. With the extension of hydraulic cylinder 7 and the movement of drive chain 8, the operation of tensioning device 11 causes the drive mechanism to return to a disengaged configuration while the drive chain slides loosely around the exterior surface of helical pile 2 . This movement may be referred to as a return stroke and occurs without rotating the pile.

It will be appreciated by those skilled in the art that the reciprocal movement of drive mechanism 5 between the power and return strokes described above will cause drive mechanism 5 to repeatedly engage and disengage the exterior surface of the helical pile, effectively causing the pile to be ratchetted into the ground through the application of successive, spaced apart, power strokes. Depending upon the hardness and characteristics of the ground through which helical pile 2 is to be driven, the relative strength of tensioning device 11 may have to be adjusted to prevent slippage of chain 8 about the pile's surface. Where tensioning member 11 is a spring, the spring may be replaced with a stronger string having a greater spring constant. In addition, a spring tensioner 14 (see Figure 11) may be used to place the spring in a constant state of tension. Alternatively, where tensioning device 11 is a hydraulic or pneumatic cylinder or an electric solenoid, adjustments may be made to increase the amount of tension that hydraulic cylinder 7 must apply to drive chain 8 before the chain is permitted to move. The portions of the links of drive chain 8 that contact the exterior surface of helical pile 2 may also be fitted with small gripping teeth or coated with an abrasive substance to help enhance the friction between the

chain and pile 2 and to prevent slippage during the power stroke. In still a further embodiment drive chain 8 may be wrapped around the exterior of the helical pile a number of times to increase the surface to surface contact between the drive chain and the pile.

The drive mechanism described above will permit helical pile 2 to be rotated and screwed into the ground without the need to attach a large high torque motor to the upper end of the pile. Drive mechanism 5 may also be mounted in close proximity to the ground avoiding the need for large boom trucks when driving lengthy piles. It will also be appreciated that drive mechanism 5 does not require the welding or bolting of drive couplings onto the surface of the helical pile, and does not present a hindrance to maintaining the pile in a desired orientation. In one preferred embodiment of the invention hydraulic cylinder 7 and tensioning device 11 are rotatably attached to the frame 12 to allow both devices to be displaced in a generally vertical plane so that they may be tipped in a downward direction as the pile is screwed into the ground during a power stroke. On the return stroke hydraulic cylinder 7 and tensioning device 11 will tend to swing in an upward direction until they are approximately horizontal once again. Accordingly, the described structure allows helical pile 2 to move in a vertical direction as it is rotated without interference from drive mechanism 5.

It should also be noted that each successive power stroke will entail the application of force to a different portion of the exterior surface of helical pile 2 as the pile

slowly moves downward into the ground. Any tendency for the walls of the pile to become damaged through contact with chain 8 is therefore minimized. Further, depending upon the speed at which it is desired to turn the pile a single drive mechanism 5 may be utilized (see Figure 11) or, alternatively, two drive mechanisms may be installed on apparatus 4 as shown in Figure 2. Where two such drive mechanisms are utilized they are preferably synchronized with their power strokes opposite to one another so that while one drive mechanism is undergoing a power stroke the other drive mechanism is undergoing a return stroke. In this manner pile 2 will effectively be continuously rotated.

It should be appreciated by those skilled in the art that a variety of other reciprocating drive mechanisms could be utilized in place of the chain drive mechanism described above. Three such alternate embodiments of the invention are shown in Figures 12, 13 and 14. In each of these Figures drive mechanism 5 includes a pair of jaw members 15 that have an engaged configuration, where they grip the exterior surface of helical pile 2, and a disengaged configuration where they are released from the exterior surface of the pile. As in the case of drive chain 8, when jaw members 15 grip the exterior surface of the pile movement of cylinder 7 (ie the power stroke) will cause the pile to rotate. Movement of the piston in cylinder 7 in the opposite direction (ie the return stroke) disengages the jaws from the exterior surface of pile 2 allowing the jaws to be rotated back in an opposite direction without rotating the pile.

In the embodiments shown in Figures 12 and 13, drive mechanism 5 preferably includes a tensioner 16 to engage jaw member 15 about surface of pile 2. Tensioner 16 may be a spring, hydraulic or pneumatic cylinder, or an electrical solenoid. In Figure 12 tensioner 16 is shown as comprising a hydraulic cylinder that is used to rotate jaw members 15 about a pin 17 to allow the jaws to either engage or disengage pile 2. It will be noted that depending upon sequencing of the operation of cylinders 7 and 16 the helical pile may be caused to rotate in either a clockwise or counterclockwise direction.

Figure 13 is a variation of Figure 12 wherein the pile is generally square in cross-sectional shape, and wherein jaw members 15 effectively comprise a generally hook-like portion 18 with a rotatable gate 19. In this embodiment tensioner 16 is preferably a spring 20 that urges gate 19 toward the exterior surface of helical pile 2. The power stroke occurs when the piston in cylinder 7 is retracted, resulting in a clockwise rotational movement of the pile. During the return stroke the piston is extended outwardly from cylinder 7 and spring 20 will allow gate 19 to effectively ride over the surface of the pile to permit hook-like portion 18 to be rotated in a counterclockwise direction without a corresponding rotation of helical pile 2.

The embodiment of the drive mechanism shown in Figure 14 functions in a generally similar fashion to that shown in Figures 12 and 13, however, through the use of a significantly different structure. In Figure 14 jaw members 15 effectively comprise a first jaw portion 21 and a second jaw portion 22. Second jaw portion 22 is connected at one end to first jaw portion 21 through a pin 23. The opposite end of

second jaw portion 22 is secured to a connecting rod 24 by means of a pin 25. Connecting rod 24 is attached to the piston of cylinder 7 and provides a means to impart movement to jaw portions 21 and 22. The end of first jaw portion 21 adjacent to cylinder 7 contains a first leg 26 and a second leg 27. First leg 26 is fixed to connecting member 24 by way of a bolt or pin 28. Second leg 27 is loosely fixed to connecting rod 24 by means of pin 29 that is attached to the connecting rod 24 but received through an oversized bore 30 extending through second leg 27. Situated about the interior of first and second jaw portions 21 and 22 is a series of grippers 31 that are designed to engage and firmly grasp the exterior surface of helical pile 2.

In operation, when the piston of cylinder 7 is retracted the loose connection between pin 29 and bore 30 will effectively cause first jaw portion 21 to rotate about pin 28 driving grippers 31 into the exterior surface of the helical pile until bore 30 prevents any further movement of the jaw members relative to connecting rod 24. At that point further retraction of the piston into cylinder 7 will effectively result in a rotational force being applied to helical pile 2 through grippers 31. When the movement of cylinder 7 is reversed, with the piston extracted from the cylinder, first jaw portion 21 will rotate slightly in a counterclockwise direction about pin 28 until further movement of the jaw member relative to connecting rod 24 is halted by engagement of pin 19 with the side of bore 30. However, the small counterclockwise rotation is sufficient to disengage grippers 31 from the exterior surface of helical pile 2 such that further withdrawal of the piston from cylinder 7

enables the jaw members to be rotated in a counterclockwise direction about the exterior surface of the pile without rotation of the pile itself. In this manner the reciprocal movement of cylinder 7 will effectively be transformed into a clockwise rotational movement of pile 2. Reversing the relative positions of pins 28 and 29 so that pin 28 is a smaller pin received within a larger diameter bore, will permit the embodiment of drive mechanism 5 shown in Figure 14 to effectively drive the pile in a counterclockwise direction.

Yet a further embodiment of drive mechanism 5 is shown in Figures 16 and 17. In this embodiment drive mechanism 5 includes at least two actuating cylinders 58 and 59 having reciprocating pistons 60 and 61, respectively, that are connected to a drive gear 62. In the structure that is shown in the enclosed Figures the attachment of pistons 60 and 61 to drive gear 62 is offset by 90 degrees such that alternating reciprocal movement of the pistons will cause rotation of drive gear 62 about a centrally disposed shaft 63. In a similar fashion to that as described above with respect to the embodiment shown in Figure 2, drive chain 8 is wrapped around the exterior surface of helical pile 2 so that movement of the drive chain is capable of imparting rotational movement to the pile. In the case of the structure shown in Figures 16 and 17 the ends of the drive chain are connected and the chain forms a continuous loop that both encompasses the exterior surface of the pile and engages drive gear 62. Accordingly, reciprocal and alternating movement of pistons 60 and 61 will cause drive gear 62 to rotate in a continuous fashion, which in turn will impart a continuous rotational movement to helical pile 2. In order to maintain

and/or adjust the tension of drive chain 8 it may be desirable to include a tensioning device (not shown) which may take the form of any one of a wide variety of devices commonly used to maintain tension in a chain.

As the helical pile is continuously rotated the drive chain will engage the exterior surface of the pile and be rotated in unison therewith around the pile in a generally helical or screw-like path. As portions of the chain come into contact with the surface of the pile other portions will be released permitting both the pile and the chain to be rotated, while at the same time permitting vertical movement of the pile (in either an upward or downward direction) without appreciable or significant movement or displacement of the drive mechanism in a direction generally parallel to the longitudinal axis of the pile. To help facilitate the relative movement of the chain and the pile, particularly in instances where the pile is rapidly advanced into or out of the ground, drive gear 62 may be inclined relative to the axis of helical pile 2. It should also be noted that while the embodiment shown in Figures 16 and 17 includes the use of two actuating cylinders, through mechanical modification of the drive structure and the control mechanism operating the drive mechanism, one, two or more cylinders could be utilized.

Referring again to Figures 2 and 4, in one preferred embodiment of the invention apparatus 4 includes at least one pile guide 32 that engages the exterior surface of helical pile 2 to assist in maintaining the pile at a desired degree of inclination. Pile guide 32 is received about the exterior surface of pile 2 and includes a series of

rollers 33 spaced apart about the exterior surface of the pile to effectively confine the pile therebetween. Preferably rollers 33 are positioned in a generally vertical configuration such that they do not interfere with the rotational movement of the pile in the event that they come into contact with its exterior surface. In addition, pile guide 32 includes a gate member 34 that may be opened or closed to allow for the pile guide to be received about helical pile 2. In the embodiment shown in Figure 4, gate 34 is held in place through a pair of pins or bolts 35. Pile guide 32 is preferably secured to frame 12 of apparatus 4. In cases where lengthy piles are to be driven, both an upper and a lower pile guide may be utilized. In such instances (see Figures 2 and 3) the upper pile guide may be secured to a vertical column portion 36 of frame 12.

Apparatus 4 may further include a soil extractor situated above the end of pile 2. In Figures 2 and 3 the soil extractor is an auger 37 that is operatively connected to a rotary drive member 38. Rotary drive member 38 is preferably a hydraulic motor, but may also be pneumatic or electrically operated. The rotary drive member is slidably received upon vertical column 36 enabling it to be moved in a vertical plane to allow for auger 37 to be inserted into and retracted from helical pile 2. In the embodiment shown, vertical movement of rotary drive member 8 is accomplished through operation of a jack screw 39, however, it will be understood that many other manners of moving rotary drive member 38 and auger 37 in an upwardly or downwardly direction may be utilized. Such alternate methods include the use of

hydraulic cylinders, pneumatic cylinders, electric solenoids, chain drives, and other similar mechanisms.

Since helical piles are generally hollow structures with a cylindrical bore extending through them, as they are rotated into the ground their centre cavities tend to become filled or partially filled with soil. Soil within the pile tends to increase the resistance of the pile to rotational movement which has a corresponding increase in the amount of torque required to rotate the pile into or out of the ground. In addition, as soil builds up within the interior of the pile the soil tends to plug the pile's internal bore such that as the lower end of the pile is rotated further into the ground the surrounding soil can no longer enter the hollow interior of the pile and must be laterally displaced. For small diameter piles in soft formations, displacing the soil at the tip of the pile may not present much difficulty. However, for large diameter piles and in hard soil formations laterally displacing the soil at the tip of the pile can have a very significant impact on the amount of torque required to drive the pile into the ground. The presence of soil or other debris within the internal bore through pile 2 also has little effect on the weight bearing capacity of the pile. Accordingly, through inserting auger 37 into the hollow interior of helical pile 2 at least a portion of any soil or other debris situated within the pile can be removed, effectively reducing the overall weight of the structure and enhancing the ability of the pile to be driven into the ground through providing a space into which additional soil may be displaced as the pile is driven downwardly. The result is that less energy and less torque is required to drive the pile into the ground. In addition, extending the lower

end of the auger down to the bottom tip of the pile provides the ability to loosen the soil as the pile is rotated, further reducing the amount of torque required to set the pile.

An alternate embodiment of the invention where the soil extractor is a vacuum tube 55 and a vacuum head 56 is shown in Figure 15. In this embodiment, rather than augering soil from within the interior of pile 2 a vacuum tube 55 may be used to remove soil and other debris from the pile. To assist in loosening and extracting the soil inside the pile the vacuum tube 55 may include a water jet 57. Water expelled through jet 57 not only loosens the soil within the pile but may be used to fluidize the soil making it easier to extract under suction. In addition to auger 37 and vacuum tube 55, it should be understood that various other means of removing and or loosening the soil within the hollow interior or helical pile 2 may be utilized.

In accordance with another one of the preferred embodiments of the invention, apparatus 4 further includes a vertical loading head 40. As indicated in Figures 2 and 3, vertical loading head 40 is mounted upon vertical column 36 of frame 12 and is moveable in an axial direction along the length of column 36, generally parallel to the longitudinal axis of helical pile 2. Where vertical column 36 is a standard I-beam vertical loading head 40 maybe secured thereto through the use of a pair of plates 41 that form a channel within which the flange portion 42 of column 36 maybe received (see Figure 6). In this manner the vertical loading head will be secured to vertical column 36, but at the same time permitted to slide axially along

the length of the column. In the embodiment of the invention shown in Figures 2 and 3, vertical positioning and movement of loading head 40 is accomplished through the use of a cylinder 43 which may be hydraulic, pneumatic or electrically operated. It will, of course, be appreciated that very wide variety of other methods of attaching vertical loading head 40 to column 36 may be used in conjunction with an equally wide variety of methods of positioning and moving the vertical loading head along the length of the column. Other methods of imparting vertical movement to loading head 40 include the use of jack screws, drive belts, drive chains, and various gear drive systems powered by electric, hydraulic or pneumatic motors.

Referring to Figures 6 through 10, vertical head 40 includes generally symmetrical jaws 44 and 45 which having pile engaging members 46 and 47 that are releasably securable about the exterior surface of helical pile 2. Jaws 44 and 45 are typically secured to a frame 48 of loading head 40, which in turn is secured to vertical column 36 through the use of plates 41 as described above. A piston 49, positioned between jaws 44 and 45, provides the means to open and close the jaws about the exterior surface of the pile. Through operation of piston 49 vertical loading head 40 is provided with an engaged position with pile engaging members 46 and 47 releasably secured about the exterior surface of helical pile 2 (see Figure 6), and a disengaged position with pile engaging members 46 and 47 free from contract with the exterior surface of the pile (see Figure 7). When jaws 44 and 45 are in their disengaged position they are preferably separated by distance large enough to allow for the pile to be received between the jaws. The engagement of the jaw members with the

surface of the pile permits the application of a vertical or longitudinal (relative to the axis of the pile) force to be applied to the pile. The ability to apply such a longitudinally oriented force can be of assistance in helping to urge the pile downward where the pile is being installed in a clay or hard ground formation. Alternately, a vertically upward directed force can be of use when trying to extract a pile from the ground.

While vertical loading head 40 is applying a longitudinally oriented force to the pile it must also permit the pile to freely rotate. To this end, in the embodiment of the invention shown in Figures 6 through 10 pile engaging members 46 and 47 are equipped an internal semi-circular groove 50 into which are received a series of bearing plates 51. Bearing plates 51 contain grippers 52 on their interior surface that firmly grasp the exterior surface of helical pile 2 when a clamping force is applied to the bearing plates through movement of jaws 44 and 45 to their engaged position. That is, as jaws 44 and 45 are moved toward the exterior surface of helical pile 2, pile engaging members 46 and 47 will drive bearing plates 51 inwardly toward the pile until grippers 52 firmly engage the pile's exterior surface. At that point a vertical load (which may be in either the upward or downward direction) applied to loading head 40 will be transmitted directly to the pile through bearing plates 51 and grippers 52. At the same time, since bearing plates 51 are received within grooves 50 in pile engaging members 46 and 47, the pile will be free to rotate under the influence of drive mechanism 5. Grease or various other lubricants may be applied between bearing plate 51 and groove 50 to reduce the frictional contact

therebetween. It should also be noted that while bearing plates 51 are shown as generally plate-like elements, a variety of other bearing structures could equally be employed.

With a complete and thorough understanding of the preceding description of apparatus 4, it will be understood that the apparatus presents a means to rotate and to assist in the installation of a helical pile through the use of a drive mechanism that may be mounted close to the ground without the need for large boom trucks or derricks. The apparatus also allows for the rotation of the pile without the use of couplings or drive members that must be welded, bolted or otherwise fixed to the pile. The described apparatus provides a simple, efficient and cost effective manner of rotating the pile and turning it into the ground. Through the use of one or more pile guides 32, the vertical orientation of the pile can be maintained at virtually any desired angle. The incorporation of vertical loading head 40 into apparatus 4 provides an operator with the ability to apply a vertical load to the pile (in either an upward or downward direction) to assist in either installing or extracting a pile. In situations where hard or wet ground formations are encountered, auger 37 may be operated to extract a portion of the dirt or other debris within the hollow interior of the pile to further aid in its installation or removal.

As discussed, apparatus 4 may include one, two or more drive mechanisms that may be operated in unison to increase the amount of rotational force available to be applied to the pile. Alternatively the drive mechanisms may be operated sequentially

so that the combined reciprocal movement of each individual drive member results in a constant rotation of the pile. Furthermore, relatively simple adjustments to drive mechanism 5 allows the drive mechanism to rotate the pile in either a clockwise or counterclockwise direction as may be necessary to install or extract a pile. Where the drive mechanism is a chain drive, reversing the direction of pile rotation is as simple as wrapping the chain around the pile in the opposite direction. Where tensioning device 11 is a hydraulic cylinder, a pneumatic cylinder, an electric solenoid or similar device, reversing the direction of pile rotation can be achieved through reversing the stroke on cylinder 7 and device 11. In the case where the tensioning device is a hydraulic or pneumatic cylinder reversing the operation of the cylinders could be accomplished through the use of reversing values on the cylinder supply and return lines.

The described structure also presents the ability to construct a compact device that can easily fit on the back of a truck or that could be independently mounted on a skid having a dedicated power source. The embodiment shown in Figures 2 and 3 represents but one example of a vehicle that may be used for purposes of transporting and operating apparatus 4. In this instance the apparatus is attached to the end of a boom 53 containing a series of cylinders 54 that can be operated to adjust the positioning of frame 12, and hence the vertical inclination of helical pile 2.

It is to be understood that what has been described are the preferred embodiments of the invention and that it may be possible to make variations to these embodiments while staying within the broad scope of the invention. Some of these variations have been discussed while others will be readily apparent to those skilled in the art.

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